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Service Manual Format
Repeater Controller

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Simple Overview

The repeater controller constructed by Group #13 is a complete control system for any two-way radio. Acting as a controller between a transmitter and receiver, it also carries on an additional role of being a controller between a radio system and a telephone line. The controller also brings the user specific features that are available in some commercial controllers.

This Repeater Controller does not require any unnecessary connections. Once this controller installed, no user servicing should be required. Two cables found in the rear of the controller, plug into a receiver and a transmitter. The plugs are each of different styles to prevent accidental connections. Each plug contains two grounds, a status line, and an audio line. The connectors currently on the controller are Cinch type, and may be easily changed to interface with other devices. Additional connections required are the power connections. Banana Plugs are currently employed to interface the unit to a DC power supply. The power lines along with the two cinch connectors are all the connections required for the controller to control the basic function of the repeater according to FCC Rules Part 97. For a basic hookup, see Figure 1.

If the user wishes to use the telephone capability of the controller, the must only connect a U.S. telephone line to the system. The use of a specially modified telephone is used for the autopatch feature to function. Several types of telephones may be modified to function with this system. The modified telephone is one such that a 12-volt signal will simulate the lifting of the handset from the base. Modifications of a telephone is discussed later in the manual.

A telephone line should be plugged into the controller as seen in Figure 2. The Handset from the telephone should be plugged into the other outlet on the controller box to establish an audio link between the telephone and controller. Another device for correct operation should be the RCA plug, which plugs into a modified telephone.

Figure 1. Diagram of Controller Connection

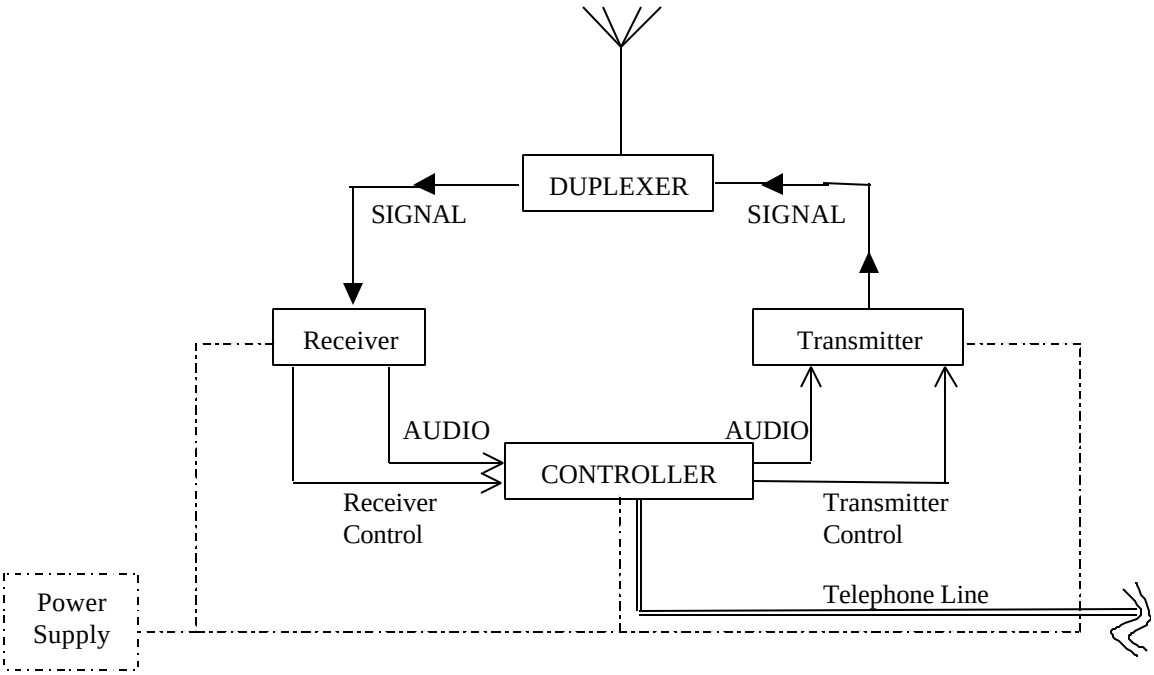


Figure 2. Telephone Connection

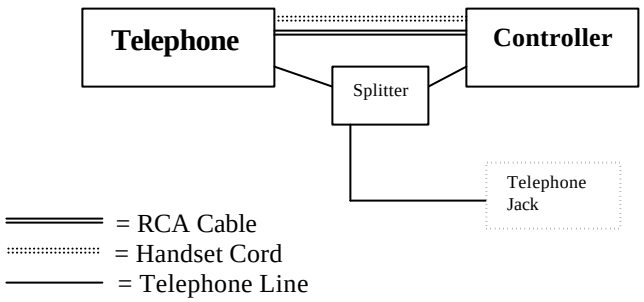
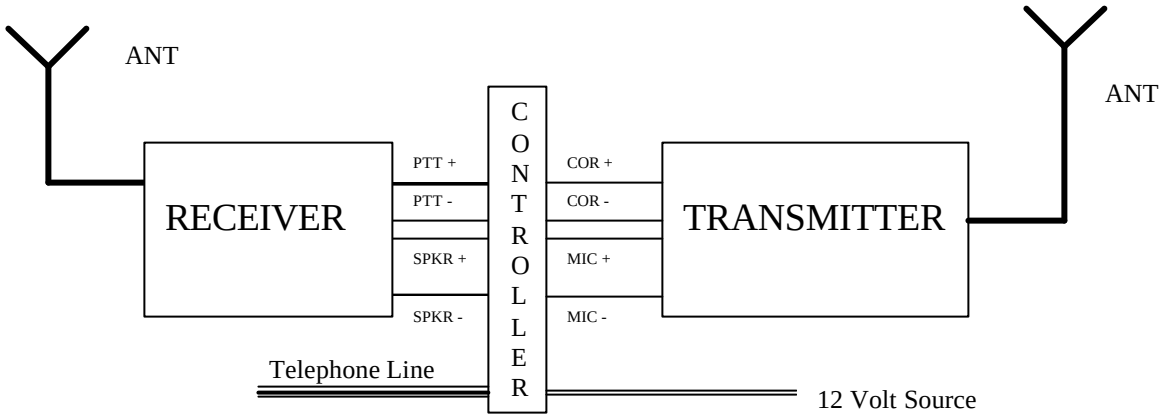


Figure 3. Diagram of Controller Connection



SPECIFICATIONS

Functions Control Joint Operation of: One Transmitter & One Receiver

Power Requirements 12 to 15 VDC @ 650 mA max. (9.0 Watts)

Fuse Requirements 4/5 Amp Fast Blow

Temperature Operation: 0 - 70 Degrees Celsius (32-158 Degrees Fahrenheit)
Storage: -20 - +85 Degrees Celsius (-4 -185 Degrees Fahrenheit)
Humidity: 0-100% No Condensation

Dimensions (Case) 6.00" H X 6.00" W X 8.00" L
(15.24 cm H, 15.24 cm W X 20.32 cm D)

Reaction Time DTMF Tone: <20 ms Carrier Detect: <25 us

Time-Out Timer User Selected Duration: Between 1 and 3 Minutes

Telephone Interface Ring Detect: 75Vrms 20Hz Pulse of 2 Second Duration
Audio: 300-3,300 Hz with 5-500mV peak-to-peak
Speaker: 16 ohms
Microphone: 600 ohms

Receiver Interface 0 - +5 Volts Digital Signal for **C**arrier **O**n **R**elay **(CAR)**
+5.0 Volts: Receiver Inactive
0.0 Volts: Receiver Active
Impedance: 10,000 ohm | 0-500mV peak-to-peak

Transmitter Interface 0 - +12 Volts Digital Signal for **P**ush **T**o **T**alk **(PTT)**
+12.0 Volts: Receiver Inactive
0.0 Volts: Receiver Active
Impedance: 600 ohm | 0-500mV peak-to-peak

Tones Morse Code: (2,000 - 4,000 Hz) Frequency and Level as user adjustable
DTMF Generator: Touch Tone Frequency Standard Distortion = 5% Frequency Variation = +/- 1%
DTMF Receiver: Touch Tone Frequency Standard Distortion = 5% Frequency Variation = +/- 1%

Remote Control Password: 4 User Selected digit for activation/deactivation
Autopatch: 1 User Selected digit for activation/deactivation
Valid digits: '1234567890ABCD#*'

Weight 5.2 lb. (1.81 kg.)

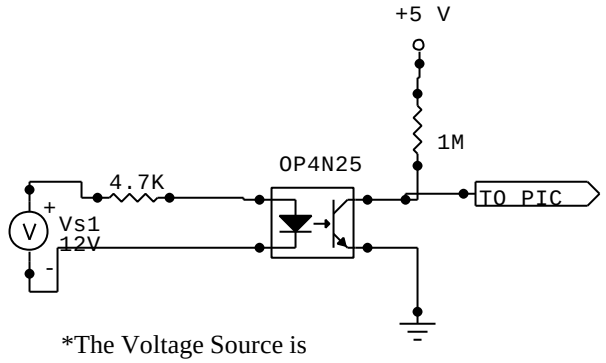
Detail Descriptions

Carrier Operated Switch (COR)

The Carrier Operated Switch (COR) is an internal switch inside the receiver. This switch, mechanical or solid-state, serves only one purpose. The COR signals the controller that a signal is present and being received. The digital signal, informs the controller to activate, or power up, the transmitter.

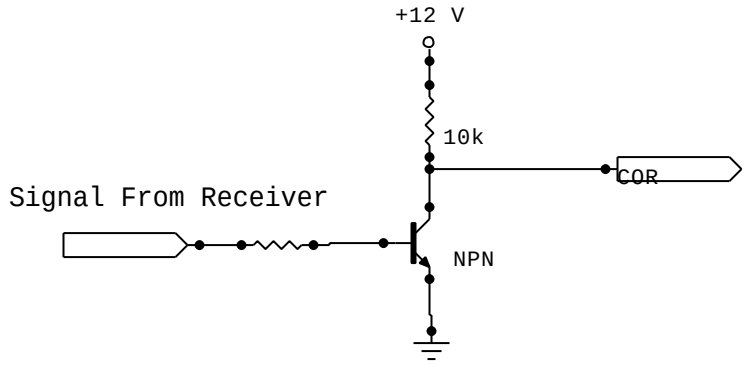
The Carrier Switch employed on the controller utilizes a an Optocoupler from Infineon Technology® SFH610A. The Datasheet for this Optocoupler is included with this manual.

Figure For COR Detect Circuit



*The Voltage Source is found in the Receiver

Figure For COR Circuit in Micor Receiver



Signals from different Receivers have differences in their voltage level indications. This controller's design will accept any voltage below 2.8 Volts, as a signal being present. Any voltage above 5.1 volts will be insufficient to activate the Optocoupler, which will cause the controller to determine that a signal is not present. Employing a voltage between 2.8 and 5.1 Volts should not be performed due to uncertainties in the transistor's operating state.

NOTE: The COR is considered to be Active Low. If the repeater COR is Active High, a relay, NPN transistor, or a 7404 TTL gate can easily be installed between the controller and receiver to alternate the signal status.

Push-to-Talk (PTT)

The Push-To-Talk (PTT) signal is easily interfaced with the transmitter. The Carrier Switch employed on the controller utilizes an Optocoupler from Infineon Technology® SFH610A. The Datasheet for this Optocoupler is included with this manual.

In order to key the transmitter, the PTT line must only be pulled to ground. The PTT line, at open circuit conditions, is found to have a 12 Volts potential on a Motorola Micor Transmitter. Transmitter keying requires the draw of 12 mA or more. The Optocoupler is configured in the controller to sink as much as 50mA. If the requirement of additional current draw is needed, the user might consider using a high power or high gain transistor on the PTT line between the controller and transmitter.

PTT Circuit In Controller

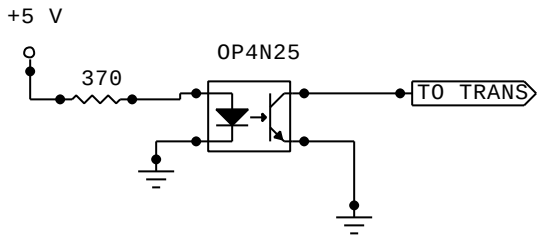
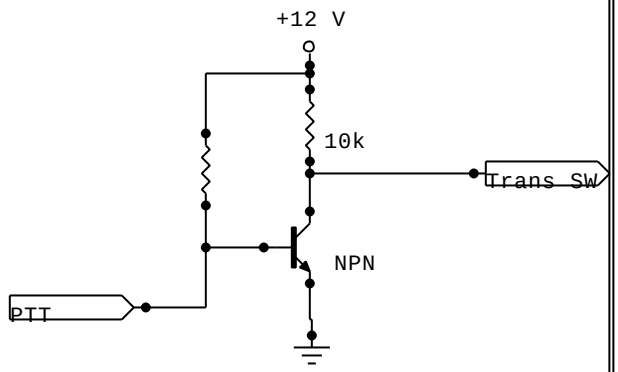


Figure For PTT Circuit in Micor Transmitter



**PTT is From Controller*

**This is not the actual circuit. Actual Circuit is Unknown*

Receiver Audio

Audio relayed through the controller t be delivered to the transmitter. The relaying of the audio is accomplished by the Receiver and Transmitter Audio Lines. There are a few other audio sources that either are generated by the controller or are external audio sources.

Audio Sources are:

1.) Receiver
2.) Telephone
3.) Morse Code Generation Circuit
4.) DTMF Generator

All Audio is sent through an Audio Amplifier. The Audio Amplifier used in this controller is a LM386 manufactured by National Semiconductor. The specification sheet for the LM386 is included with this document.

1.) Receiver Audio Source:

The Receiver Audio is internally attenuated with the use of resistors. With no load, the audio from the receiver is 4 Volt's P-P. With the audio directly applied to the transmitter's audio lines, the signal of the audio is greatly attenuated. The attenuation of the audio signal indicates that the receiver is incapable of driving a large load (the transmitter audio input lines). The transmitter requires a strong 1-Volt P-P signal for adequate sound reproduction. Along with the receiver audio, the telephone audio must be relayed to the transmitter

2.) Telephone Audio

The Telephone Audio is derived directly from the Handset cord. The Handset Microphone Audio has a voltage range of 0.5 mV P-P. The Microphone is continuously being sent audio regardless if the telephone is being used.

3.) Morse Code Generation Circuit

The Morse code Generation Circuit is generated on the main control board and sent to the Audio Board. This audio, a PWM signal from the PIC chip, is passed through a Null Amplifier that creates a more sinusoidal wave instead of the sharp square wave generated directly from the PIC chip. The wave from the Null Amplifier is approximately 2 Volts in Magnitude with a DC offset of 0.7 volts. The 0.7 volt offset requires a capacitor to filter out the DC offset.

4.) DTMF Generator

The DTMF Generator generates DTMF tones that will be sent out to the telephone. The DTMF tones, generated by a Holteck HT9200A DTMF Generator, are sinusoidal 1 Volt waves with a +3 Volt DC offset. The DTMF to be sent are from the PIC chip in a four bit address format. The DTMF Generator will only transmit DTMF tones when the chip is enabled and a four valid data bits are sent to the chip. To change the tones being sent, the Chip must be deselected before new data is sent to the chip. The DTMF tones can easily be viewed using an oscilloscope.

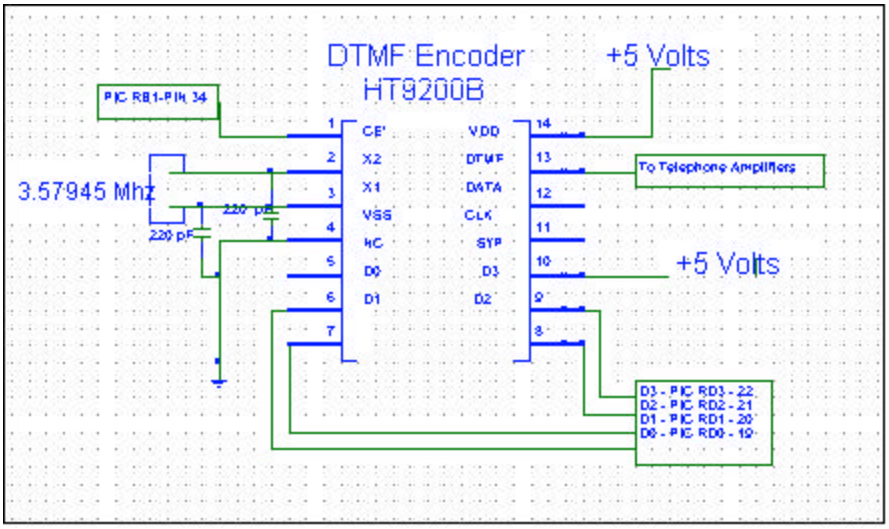
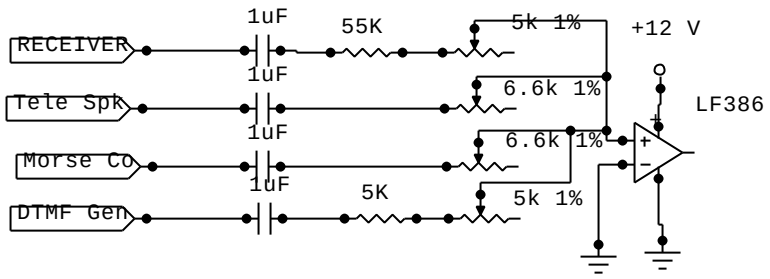
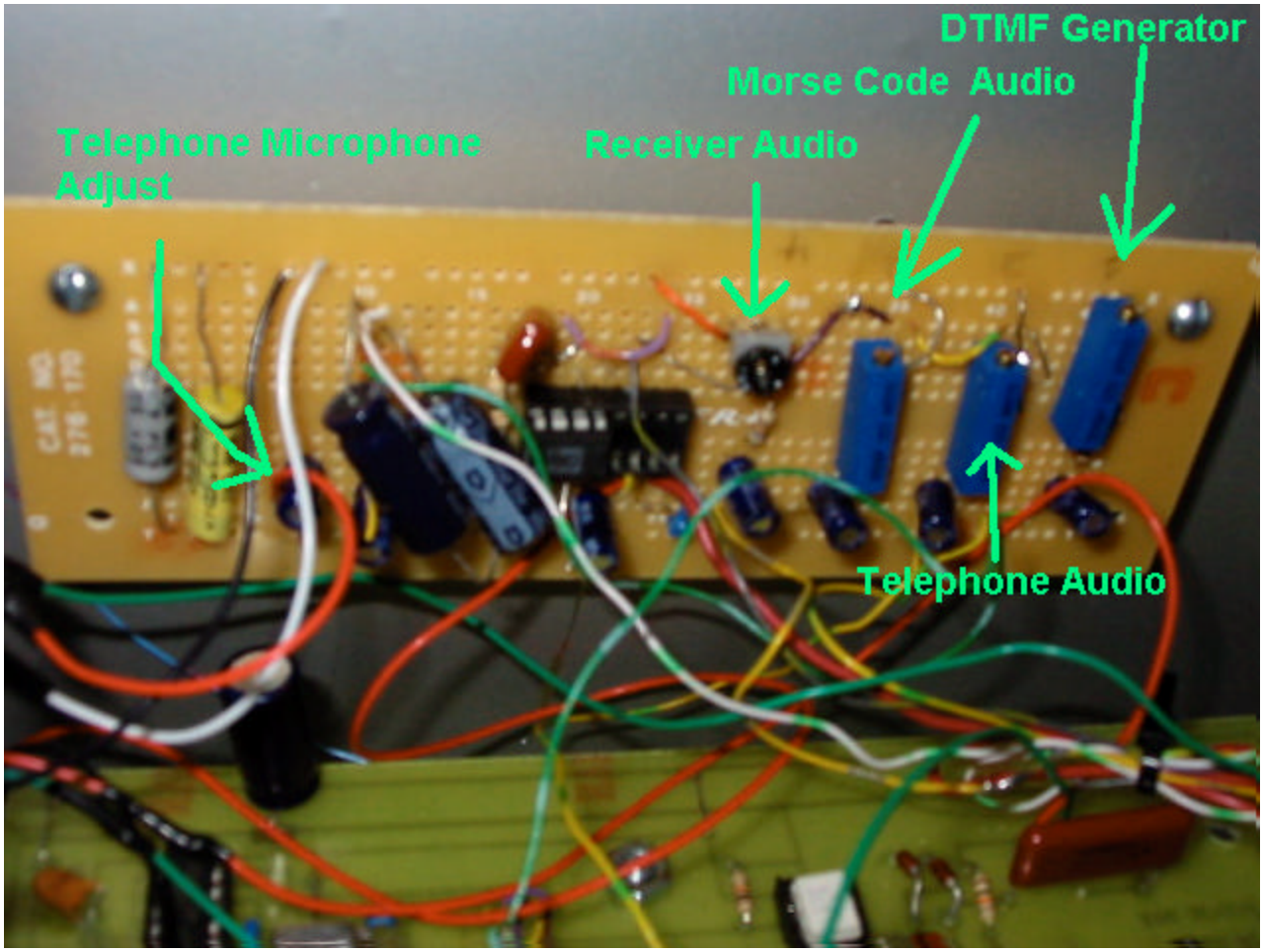


Figure: Circuit Of Audio Amplifier Board



Pictured above is the Audio Board in the Controller. The values of the variable resistors indicate their current operating setting.



Pictured above is the Audio Board found on the right side of the Controller. The LM386 Audio Amplifier is Visible in the center of the board.

Transmitter Audio

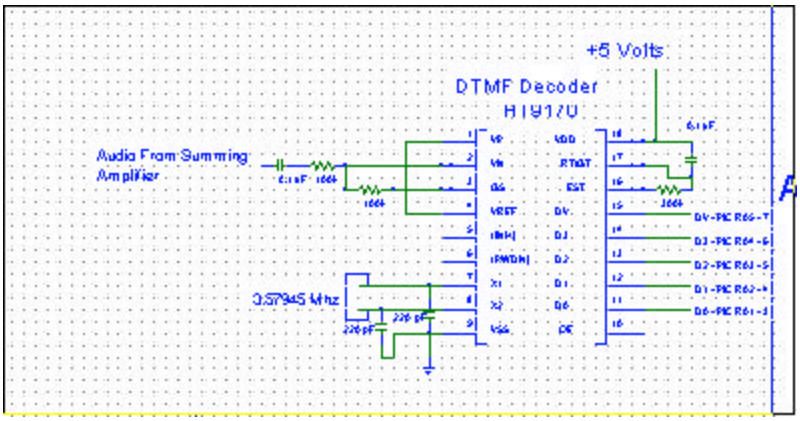
The Audio is supplied by the controller to the Transmitter. The Audio for the transmitter is actually divided between three items:

1.) Transmitter Audio Lines
2.) DTMF Receiver
3.) Telephone Microphone

A large portion of the audio goes into the Audio lines of the transmitter while a small portion of the Audio is fed into the microphone of the telephone through a matching network. The Audio going into the repeater is adjusted such that the required 1-Volt P-P is delivered. If a stronger signal is desired to be delivered into the transmitter, the user can adjust the gain of the individual inputs of the Audio Amplifier mentioned above.

DTMF Decoder

The DTMF Receiver utilized in the repeater controller is a Holteck HT900B. The data lines for this chip are connected directly to the PIC processor. This chip, when it decodes a valid signal, will hold the data on its bus for as long as the tone is depressed.

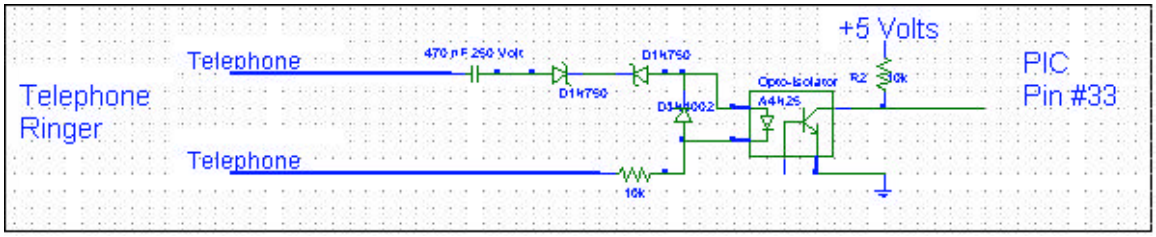


Telephone Microphone

The Telephone Audio must be correctly coupled to the audio lines. The microphone input signal must not exceed +/- 75mV or over modulation, will result. A DC voltage is also present on the Microphone line. The employment of a 1-uF capacitor in the circuit is to prevent any DC voltage flowing into the Audio Amplifier and other circuitry.

Ring Detection Circuit:

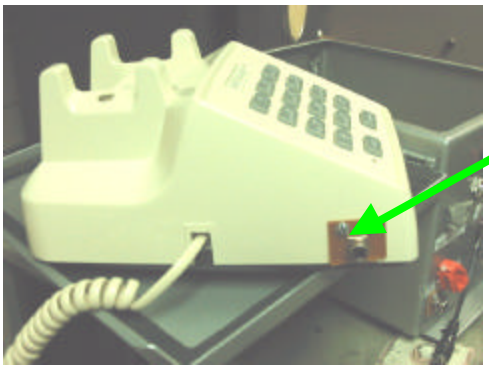
A Ring is defined as an AC signal with a magnitude of 75 Volts held for 2 seconds with a pause of four seconds. The controller detects a ring so that it knows to activate the telephone. The activation of the telephone will allow the user to pass DTMF Touch Tones into the controller and temporarily disable or enable the transmitter. The telephone detection circuit uses very few components. The Two Zener Diodes prevent any successive voltage from entering the circuit by clipping the signal. The 10K and 470nF capacitor absorb in excess AC and DC voltage. The Opto-Isolator isolates the controller from the high voltage generated by a ringing telephone.



The voltage at the Opto- Isolator is a sin wave of 3.5 volts. A ringing telephone can be simulated by employing a Variac. If a Variac is employed, do not exceed 75 Volts AC or damage will occur to the circuit. The Viraic is connected to the telephone line input jack. The circuit is non polarized.

Most telephones utilize a DPDT switch that is tripped with the removal of the handset. A telephone must be modified so a voltage signal will simulate the lifting of the handset. The telephone pictured below was modified for our project.

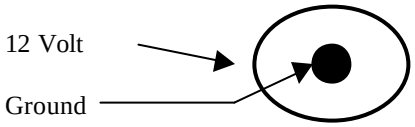
The RCA Plug matches with an RCA connector found on the controller's case.



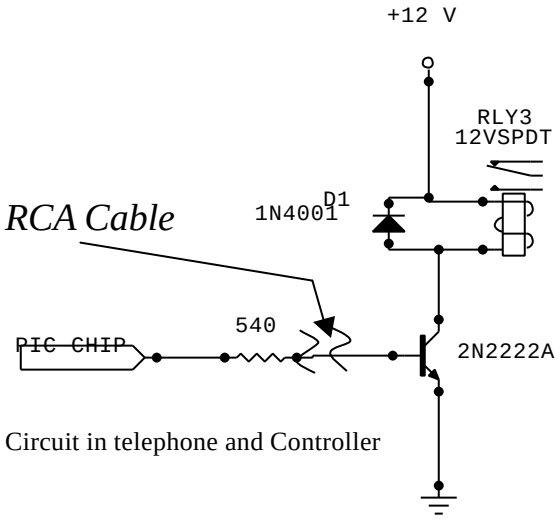
Telephone Activation Line

Telephone Activation Line

The RCA Jack's can be connected to each other by using a standard cable. Although the employment of a mechanical relay is used in the switching, the plug is polarized. The plug is polarized due to the implication of a diode on the relay. The diode is to prevent excessive current flowing into the controller when the Relay coil is un-energized.



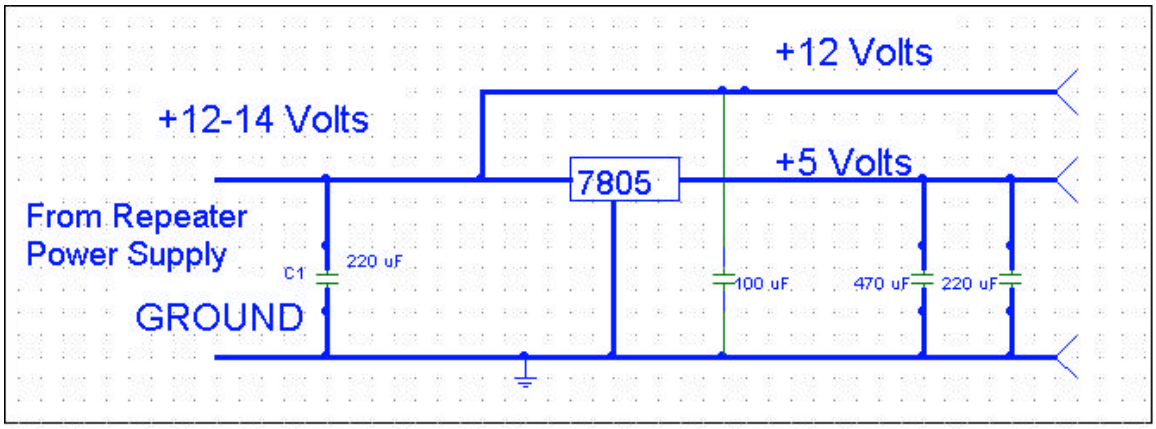
A 2N2222 NPN Transistor activates the relay inside of the telephone. The Transistor is controlled by the PIC Processor and easily pulls in relay. The relay latching in very audible and can easily be heard.



Circuit in telephone and Controller

DC-DC POWER

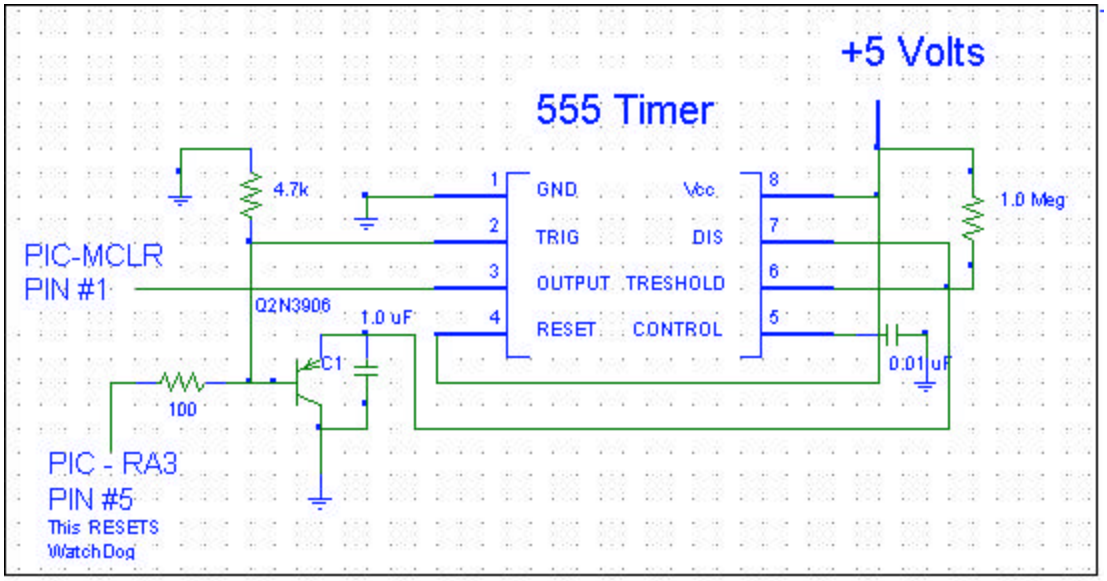
The power source for the controller is supplied by the Repeater's power supply. The power supply should be capable of generating a clean, free of noise, 12 Volt supply. During the construction of the controller, it was discovered that if a power supply has more than 0.35 Volts of AC on the line, the DTMF Decoder and Encoder are incapable of accurately decoding or generating the DTMF tones. The installation of a capacitor(s) on the DC power line can assist in the filtration of any noise. (Adequate capacitors are currently installed into the controller.)



A LM7805 Voltage Regulator is employed to generate a 5-volt supply from the 12-Volt Supply. The controller uses no more than 300mA of current from the 5-Volt side. The low current draw and relative low input voltage does not require that a heat sink be utilized on the Voltage Regulator.

WATCHDOG TIMER

A Watch Timer is utilized in the final circuit design. The WatchDog Timer will reset the processor after a period of processor inactivity. The processor, while running its program, sends impulses to the Watch DogTimer and resets the time. The resetting of the watch dog timer resets the timer but not the processor. The current configuration of the watch dog timer will reset the processor when 30 seconds of non-activity from the processor detected. The microchip sends a low impulse to reset the watchdog. If the impulse is held low, the watchdog timer will never be released from its reset position.



CINCH PLUGS

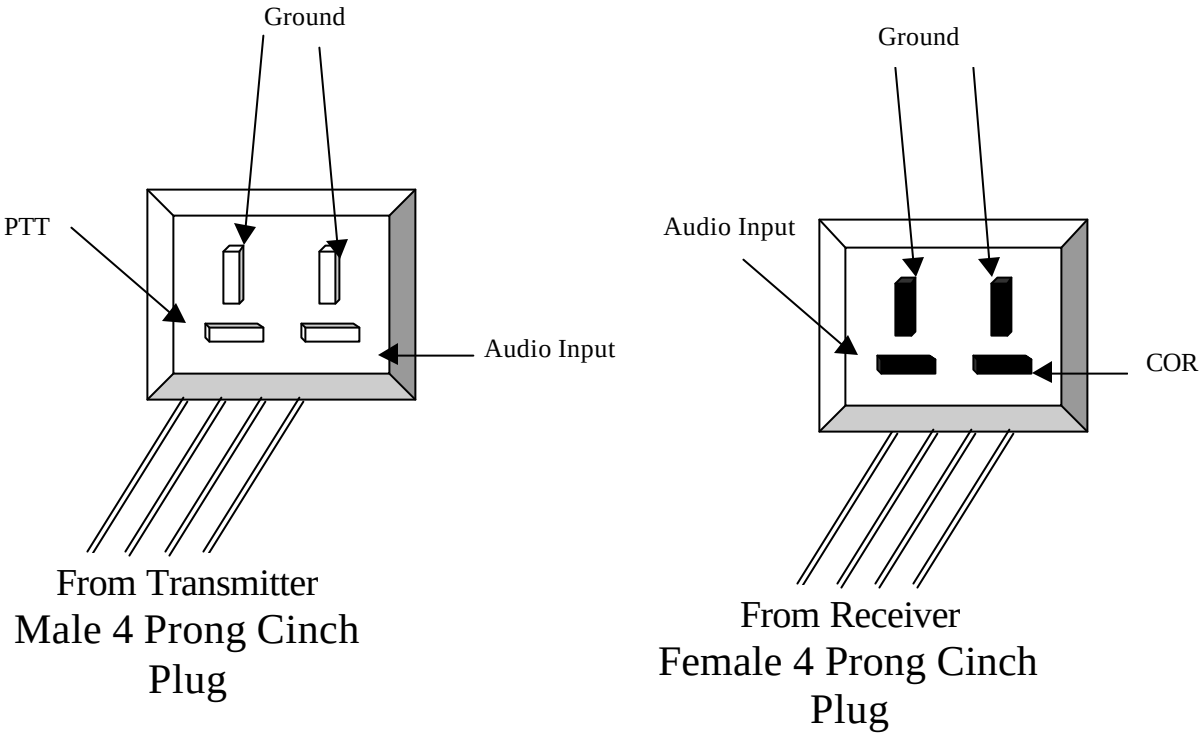


Figure 1.) Plugs found on Motorola MICOR Repeater

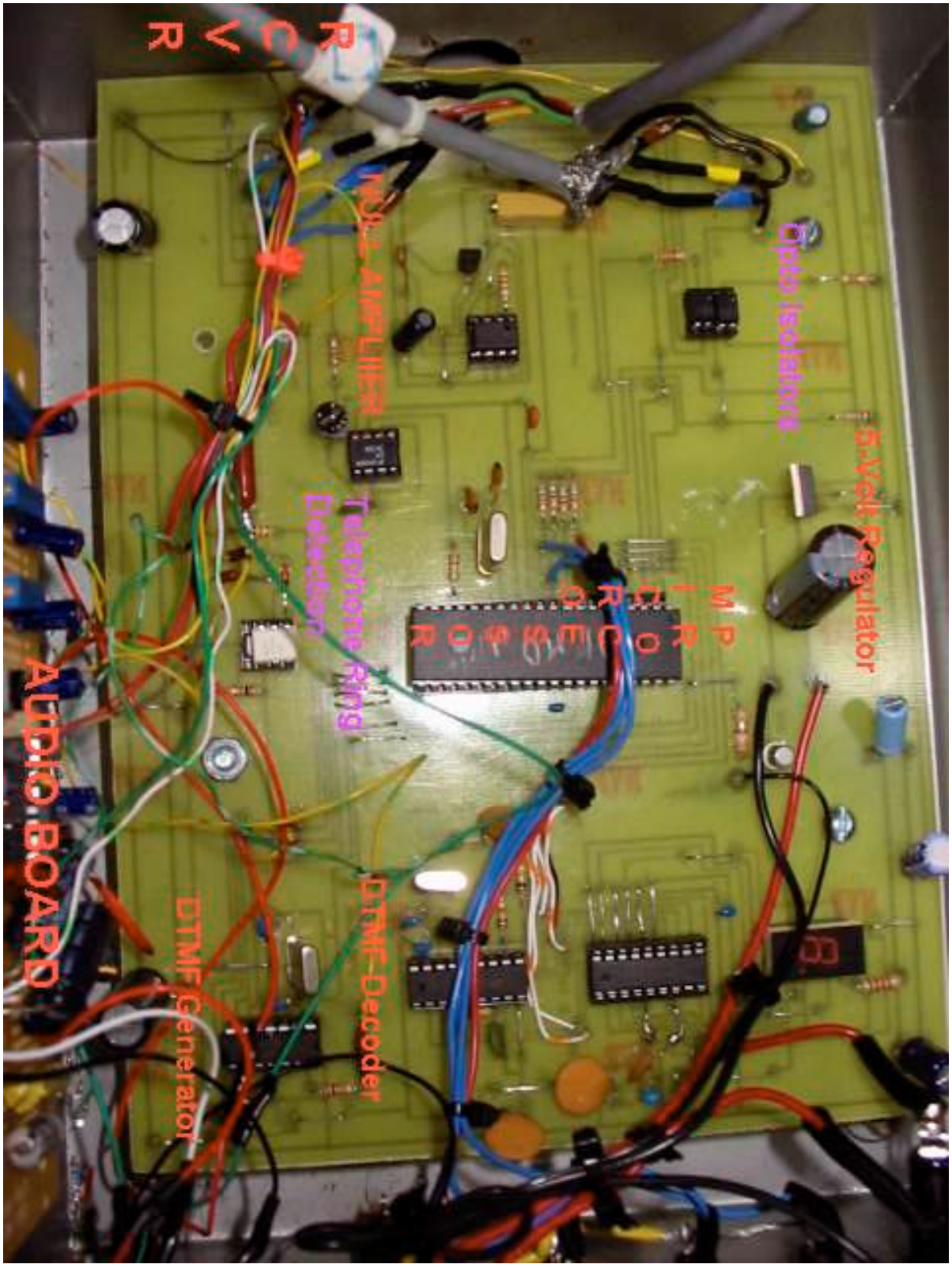
From analyzing repeater circuit:

PTT= Push To Talk: Activates the Transmitter
COR=Carrier On Relay: Indicates the receiver is receiving a signal on its frequency.

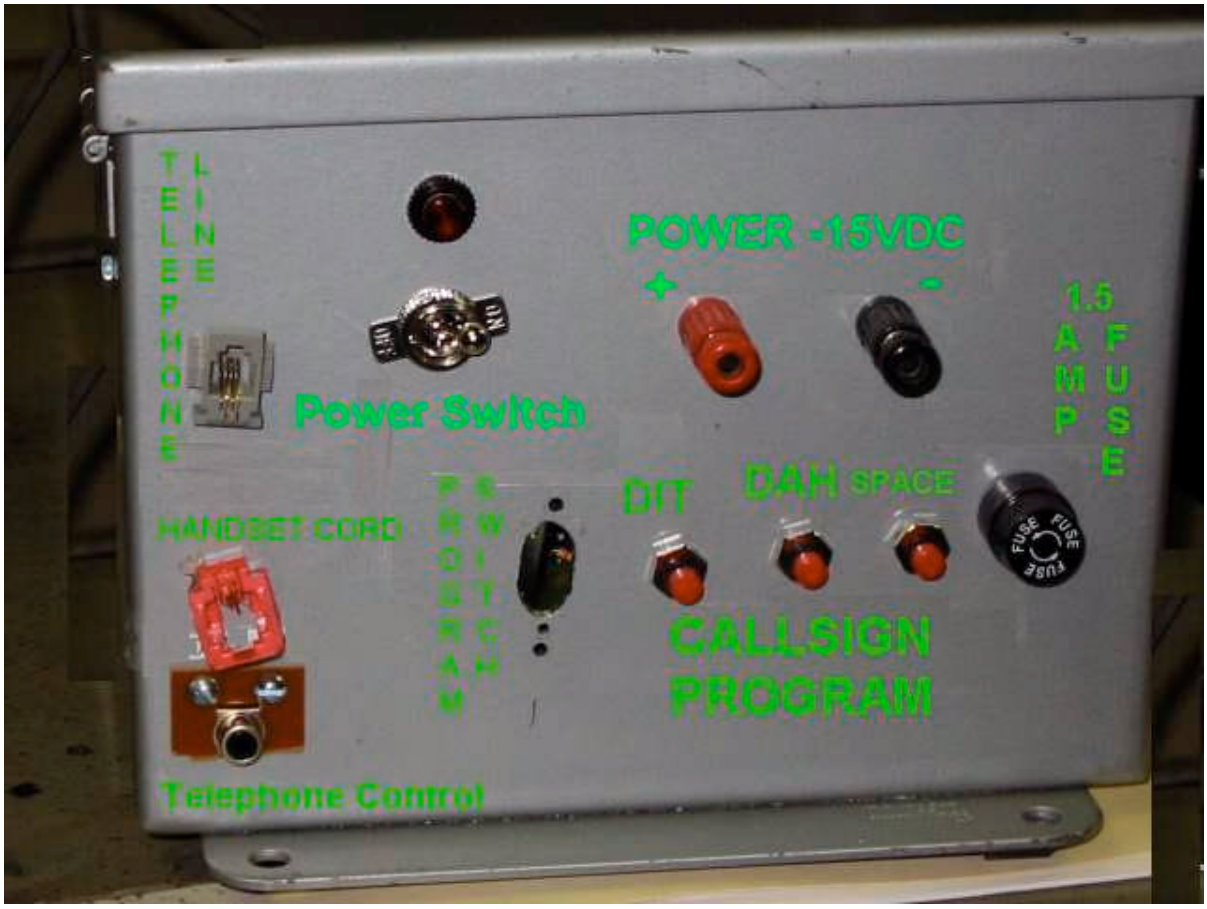
During repeater inactivity: The PTT is +12 Volts with respect to ground.
The COR has +5 volts potential

During repeater activity: The PTT drops to zero volts potential
The COR has zero volts potential

Picture of Circuit Control Board

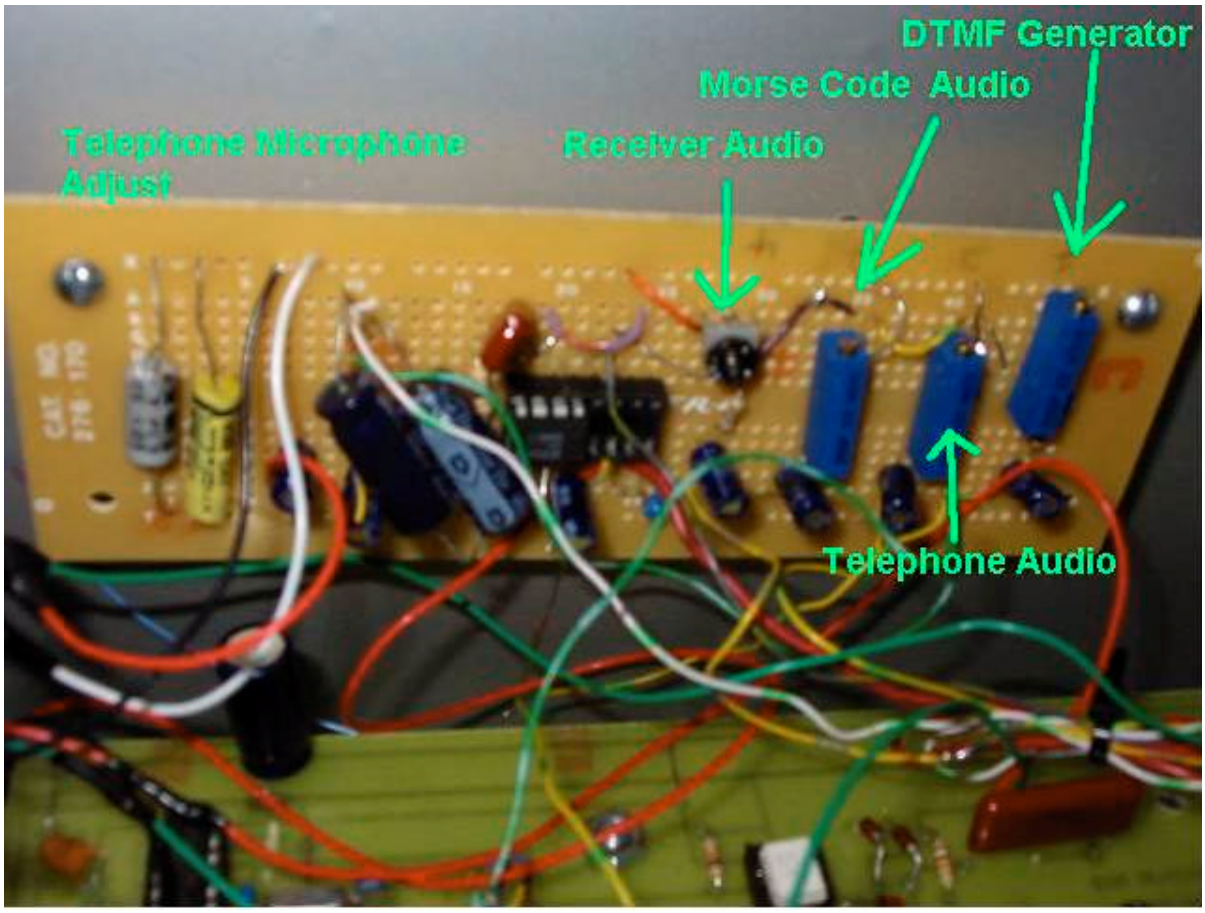


Front View of Controller Case

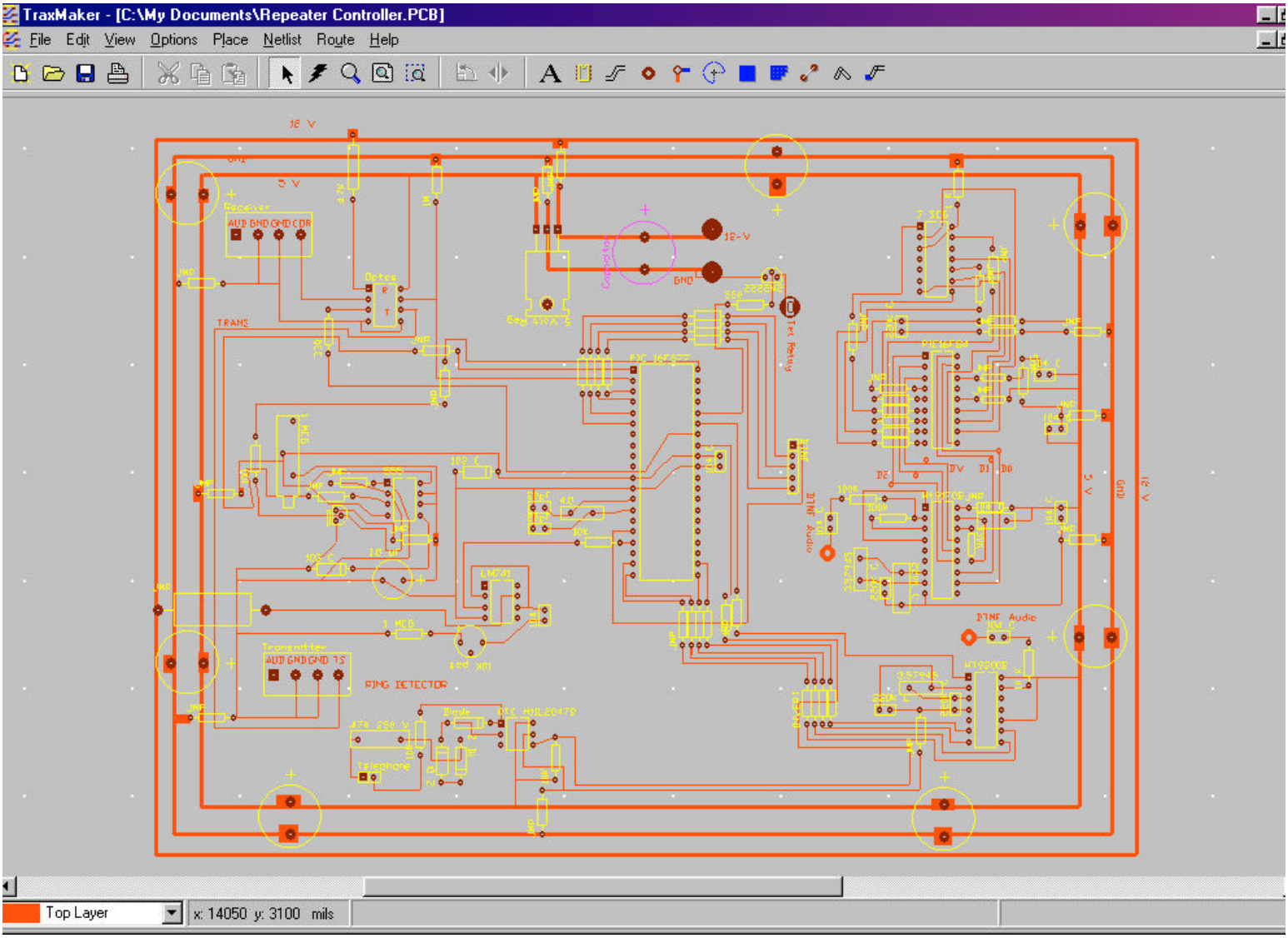


*The lines that connect to the repeater originate from the rear of the controller.

Front View of Audio Amplifier



Circuit Diagram with components and their description.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Top Layer
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